May 1992

BEST PRACTICE PROGRAMME

Good Practice – Case Study 92

AUTOMATIC PURGING ON COLD STORE REFRIGERATION PLANT

Case Study Objective
To demonstrate the energy savings and other benefits of using an automatic air purging system compared with purging manually on a weekly basis.

Potential Users
Operators of refrigeration systems with compressors drawing more than 100 kW.

Investment Cost
£8,980 (1989 prices).

Savings Achieved
630 GJ/year valued at £8,800. Saving in maintenance costs of £2,400/year (1991 prices).

Payback Period
10 months.

Case Study Summary
Purging non-condensable gases from a refrigeration system's condenser and receiver reduces system head pressure. This has the simultaneous effect of reducing compressor power consumption and increasing refrigeration capacity. High pressure cut-out problems are avoided.

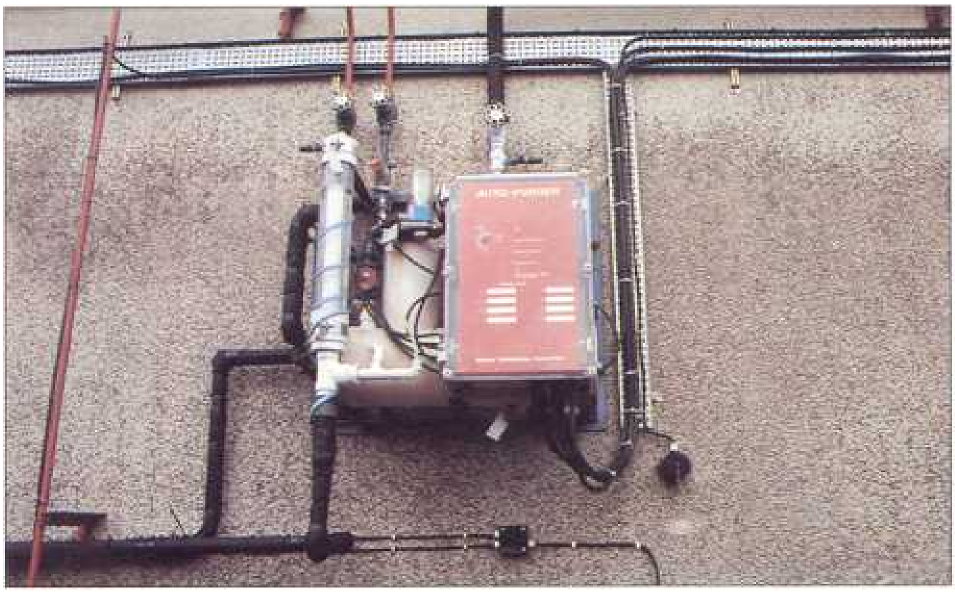
In September 1989, Exel Logistics installed a five-point automatic purger to the evaporative condenser and receiver of their ammonia refrigeration system. The plant was previously manually purged on a weekly basis. Test work has shown that when the automatic purger is switched off, the head pressure increase during the course of one week causes an 18% increase in compressor shaft power requirements from 60 kW to 71 kW under test conditions. The duty of the condenser fan operating under head pressure control also increases by around 70%.

In addition to energy benefits, the purger has reduced refrigerant loss, and the running hours of high-stage compressors have been reduced by 6%. Consequent savings in maintenance costs are worth around £2,400/year and plant operation is simplified. The purging system has worked reliably and requires minimal maintenance.

Host Organisation
Exel Logistics Temperature Controlled Services Ltd
350 Renfrew Road
Shieldhall
Glasgow
G51 4SP

Monitoring Contractor
March Consulting Group
March House
13 Park Street
Windsor
Berkshire
SL4 1LU
Tel: 0753 869346
Mr J R Graham

Equipment Supplier
Hansen Technologies Corp
98 Manor Road
Barton-le-Clay
Bedfordshire
MK45 4NS
Tel: 0582 881281
Mr S P Willison



Air Purger

Energy Efficiency Office
DEPARTMENT OF THE ENVIRONMENT

The Refrigeration System

Refrigeration to 16 cold store chambers ranging in volume from 190 m³ to 2,800 m³ is provided by pumped liquid ammonia from a two-stage plant. Room temperatures vary according to clients' requirements between approximately +4°C and −30°C. System pressure levels are varied according to store temperatures, with the low side typically being under slight vacuum.

Five high-stage reciprocating compressors of two different sizes are installed; typically, one large and one small compressor operate, discharging to a single evaporative condenser. Ammonia drains from the condenser to a horizontal liquid receiver.

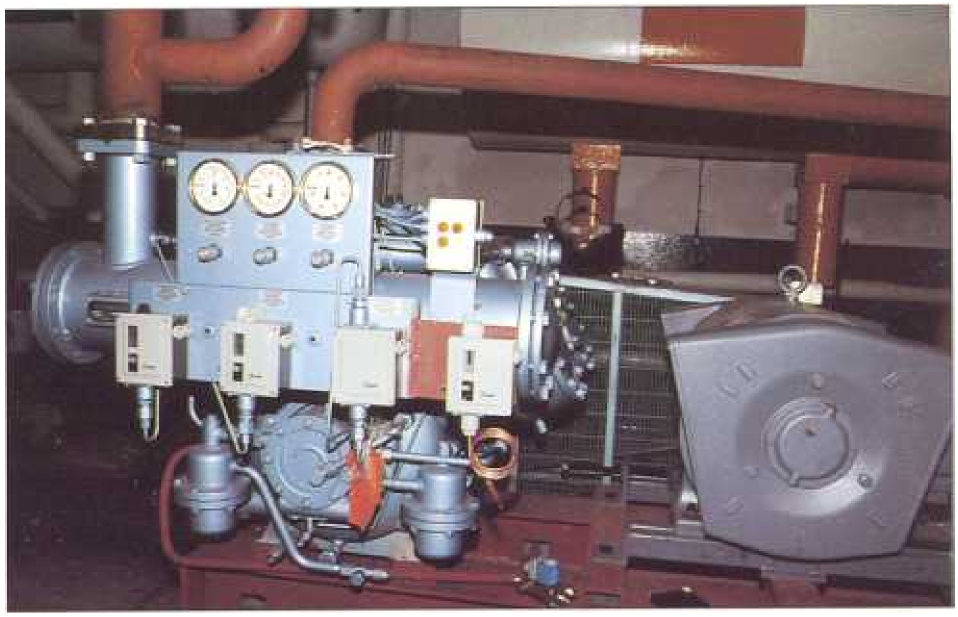
Purging Background

The presence of non-condensable gas in the condenser and receiver increases system head pressure in two ways:

- the partial pressure of non-condensable gases adds to the partial pressure of refrigerant to increase the total system head pressure;
- non-condensable gases impede heat transfer making a high condensing temperature (and hence pressure) necessary for a given condensing duty.

The increased system head pressure causes excessive compressor power consumption and reduces system capacity. Coefficient of performance (COP) is reduced.

To avoid these performance penalties, Exel manually purged their condenser on a weekly basis. This was found to be a time consuming process and some refrigerant loss was always experienced. Also, it was never certain that all non-condensables were removed. Air ingress caused head pressure to increase between manual purges and so the weekly average head pressure was always above the minimum attainable.



Small High-Stage Compressor

Air Purger (Top Left) and Receiver (Foreground)

Automatic Purger Installation and Commissioning

To overcome the problems associated with manual purging, Exel installed an automatic purging system containing the purger itself together with all controls necessary to govern the operation of up to eight purge points. Purging connections were taken from five points:

- each end of the liquid receiver;
- the upper part of each of two condenser outlets;
- the hot gas line.

A high-pressure liquid refrigerant supply was taken from the ammonia receiver. The purger suction connection was made to the low-stage compressor discharge line.

Exel installed the purger themselves in two days and found installation straightforward. The particular model of purger was chosen because it is a completely packaged unit.

Purger Maintenance and Reliability

Routine maintenance is limited to six-monthly inspection and cleaning of seven strainers used to protect solenoid valves. These valves serve the five purge points and the high-pressure liquid and foul gas inlets to the purger.

One purger failure has occurred due to a fault in a solenoid coil. Replacement was simple and cost only £15.

Energy Savings

The purger was operated one week on, one week off, between October 1990 and January 1991. During weeks in which the purger was switched off, the system head pressure increased. As a result, power consumption also increased proportionately. The curve on the graph shows the mean monitored trend with which compressor power consumption increased during those weeks when the purger was switched off. In fact, consumption increased from 60 kW to 89 kW, an average of 71 kW for the period.

For the conditions under which the refrigeration plant was operating at that time, the operation of the purger effectively reduced the weekly

average compressor shaft power consumption from 71 kW to 60 kW, a saving of 15%. Allowing for losses in the compressor motor and drive, and for changing load conditions throughout the year, it is estimated that the purger has reduced compressor energy consumption by 120,000 kWh/year, worth £6,000/year to Exel at 1991 electricity prices.

The condenser fan operation is governed by a head pressure control system, cutting in at 10.5 bar(g) and out at 6.5 bar(g). When the purger operates, the fan cycles as head pressure fluctuates. When the purger is off, the head pressure never falls enough to turn off the fan. The purging system has reduced the annual energy consumption of the condenser fan by around 56,000 kWh, worth £2,800/year to Exel at 1991 electricity prices. Hence, the total energy saving achieved by the purger is 176,000 kWh, worth £8,800/year.

Other Benefits

The automatic air purging system has brought substantial non-energy benefits. Routine manual purging is now no longer necessary. System purging after compressor maintenance is taken care of by the automatic purger; previously it might have been necessary to purge the system manually several times.

As air purging cannot now be overlooked, it is not possible for air accumulation to reach a level which causes compressor high pressure cut-off. This used to occur three or four times a year, usually when cold weather was suddenly followed by a hot day.

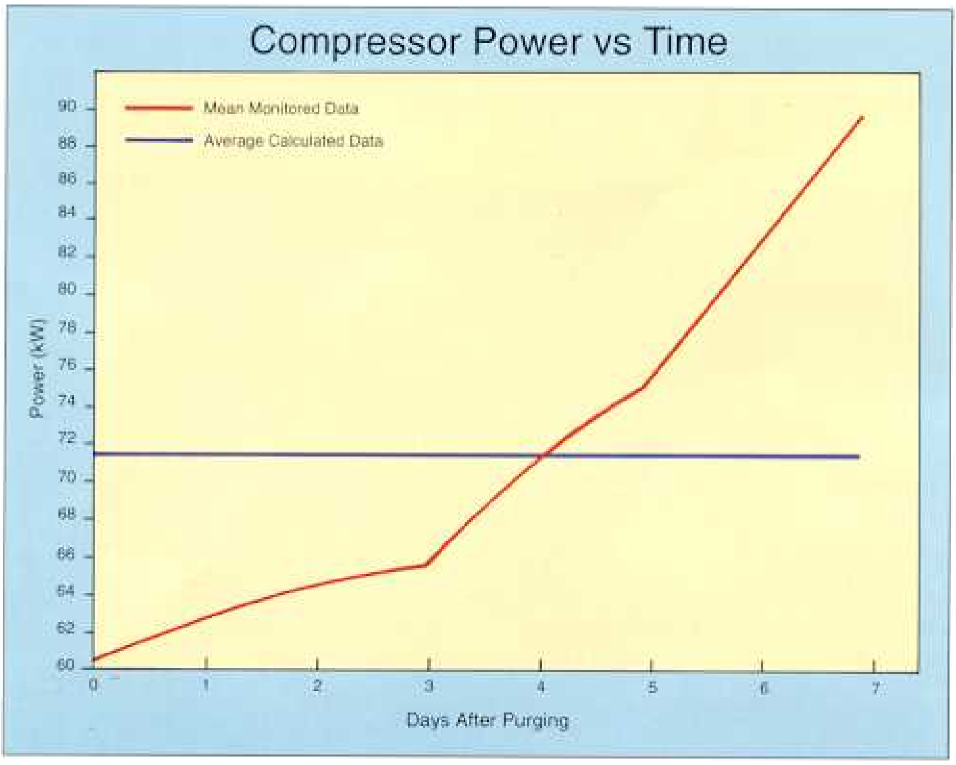
The increase in system capacity and COP has enabled high-stage compressor running time to be reduced by 6% with consequent savings in maintenance costs of £2,400/year.

Loss of refrigerant associated with purging is all but eliminated.

Economic Analysis

The total installed cost of the purger was £8,980 in September 1989. Total annual energy savings are £8,800, hence the simple payback of the installation is just over 12 months in energy terms. When maintenance cost savings are included the payback falls to 10 months.

Evaporative Condenser



Future Potential

The savings which an automatic purger will achieve are site specific. They depend, principally, on plant size and on the extra non-condensables which the automatic purging system can remove compared with the existing purging method.

Large quantities of air were drawn into the Exel refrigeration low-stage system which was continuously under vacuum. Many plants which do not operate continuously under vacuum nevertheless experience vacuum from time to time – when defrosting or if a low pressure cut-out system is used to control operation, for example. Non-condensables can also accumulate in refrigeration systems for reasons other than leakage into evacuated pipework systems. Air may be introduced during plant maintenance or charging, refrigerant can be contaminated, and refrigerant and oils can dissociate at high temperatures.

The less frequently a system is purged the higher will be the savings achieved by automatic purging. This Case Study shows, however, that automatic purging can be economic even when a refrigeration plant is purged regularly.

The typical installed cost of a multipoint purging system is likely to be £10,000. To achieve a two-year simple payback, and assuming 15% savings, implies a typical annual compressor running cost of £33,000. For continuous operation, this means a compressor power consumption of around 100 kW.

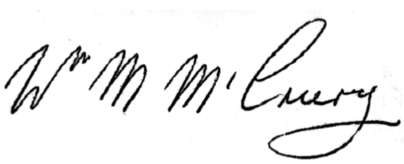
Comments from Exel Logistics

The air purger fitted at this store has now been in operation for almost two years. During this period, the planned maintenance on the unit has consisted of a six-monthly examination of strainers and filters, with a purger down-time of approximately six hours on each occasion. In the two years of operation, one breakdown occurred due to a faulty solenoid coil. The maintenance and fault diagnosis on these units is relatively simple.

Plant efficiency has improved and substantial energy savings are evident. Compressor running hours have been reduced by 6%, therefore maintenance costs have also decreased by £2,400/year. With the absence of air or non-condensables in the system, the full plant design capacity is available and the minimum power costs are achieved.

In an ammonia plant, manual purging can be haphazard and time consuming and a certain amount of refrigerant escapes to the atmosphere. If an excessive amount of air is present in the system, increased wear on compressor parts will occur and chemical breakdown of the lubricating oil is also possible.

Generally, the amount of energy and maintenance savings will depend on the efficiency of the plant prior to being fitted with a purger. Most companies employ a minimum of maintenance staff and, in some cases, proper control of non-condensables is impractical. In these circumstances the payback period could be a few months only.



W M McCreery
Chief Engineer
Exel Logistics

Exel Logistics

Exel Logistics, an NFC company, provides a contract cold storage and refrigerated distribution service to a variety of commercial organisations. The company has 22 cold stores nationwide.

The installation described here was selected as an example of Good Practice, which is one element of the Energy Efficiency Office's (EEO) Best Practice programme, an initiative aimed at advancing and promoting ways of improving the efficiency with which energy is used in the UK.

For further information on this or other industrial projects, please contact the Energy Efficiency Enquiries Bureau, the Energy Technology Support Unit (ETSU), Building 156 Harwell Laboratory, Oxon OX11 0RA. Tel No: 0235 436747. Fax No: 0235 432923. Telex No: 83135.

For information on buildings-related projects, please contact the Building Research Energy Conservation Support Unit (BRECSU), Building Research Establishment, Garston, Watford WD2 7JR. Tel No: 0923 664258. Fax No: 0923 664097. Telex No: 923220.

Information on participation in the Best Practice programme and on energy efficiency generally is also available from your Regional Energy Efficiency Office.